

## PATENT COOPERATION TREATY

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## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

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Applicant CLEGG, Andrew, Simon	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
 01 March 2001 (01.03.01)

☐ in a notice effecting later election filed with the International Bureau on:  
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2. The election ☒ was  
☐ was not

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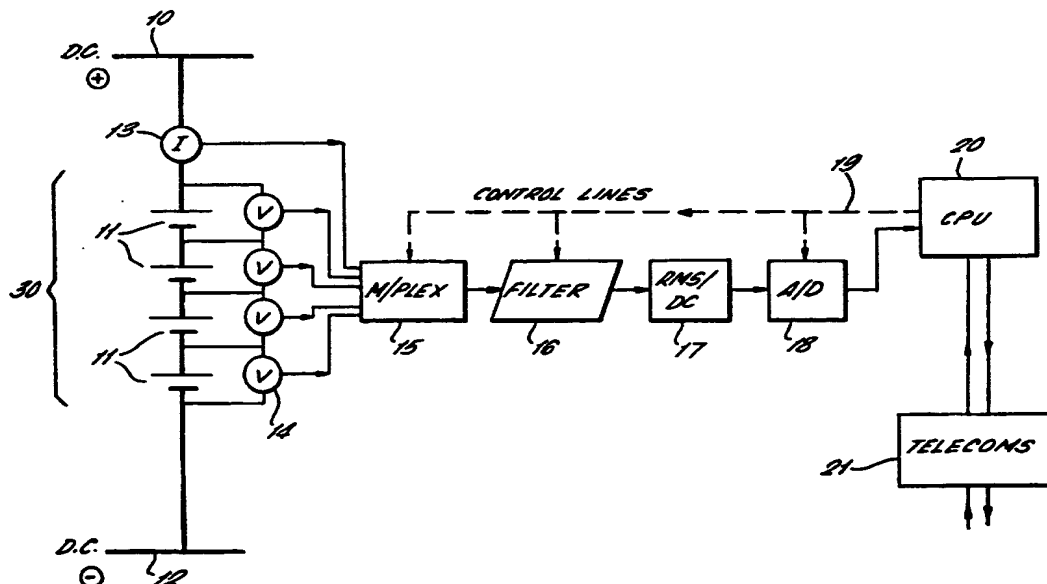
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(54) Title: **ASSESSING A PARAMETER OF CELLS IN THE BATTERIES OF UNINTERRUPTIBLE POWER SUPPLIES**



(57) Abstract: A method and apparatus for measuring the electrical efficacy of one or more battery cells for use in an uninterruptible power supply are disclosed. The efficacy is determined by making use of the ripple current which flows in the battery cells when in use in the uninterruptible power supply. Simultaneous measurement, for example, of the ripple current and a corresponding voltage component enables the internal impedance of a battery cell to be determined, the impedance acting as an indicator of electrical efficacy.

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ASSESSING A PARAMETER OF CELLS IN THE BATTERIES OF  
UNINTERRUPTABLE POWER SUPPLIES

5       The present invention relates to uninterruptable power supplies and in particular to a method and apparatus for assessing a parameter of the cells in the batteries of such power supplies.

10       Uninterruptable power supply systems are used in situations where unexpected loss of power is particularly undesirable, for example by financial institutions, telecommunications installations, the utilities, hospitals and the military. They are needed

15       where loss of power is unacceptable, for example where hospital patients rely on life support systems, or where data loss due to a computer shut down would be unacceptable as in a financial institution. The battery of the uninterruptable power supply is

20       typically the last line of defence against total shutdown during power outages.

A typical arrangement of an uninterruptable power supply is shown in Figure 1. An external alternating

25       current (a.c.) power supply 1, generally supplied by an outside utility company, is converted to direct current (d.c.) by a rectifier 2. The rectified d.c. is converted back to a.c. by an inverter 3 for supply to the power supply user 4. A battery 5 is connected to

30       the d.c. part of the system in such a way that the charge on the battery is maintained during normal operation of the power supply. The battery may typically comprise a large number of lead acid cells. Should the external power supply 1 fail for any

35       reason, the battery 5 maintains the operating voltage of the d.c. part of the system so that the power supply to the user 4 is maintained.

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Battery 5 is shown, for convenience, and simplicity, connected between the D.C. voltage and earth. In practise, however, especially on larger batteries, the battery is generally at a voltage floating with respect to earth, as supplied by the rectifiers.

Unless the battery is healthy, it may not be able to carry the required electrical load when the a.c. supply is cut off. Thus it is desirable to be able to determine an indication of the condition of the cells in the battery, so as to be able to take further action, for example by repairing or replacing a cell, if a cell is unlikely to be able to meet the power demands whilst the a.c. supply is cut off.

Batteries are generally manufactured with a certain life span that is dependent on environmental criteria and the number of discharges supplied by the battery. Some of the discharges will be due to use of the battery during a.c. power cuts, but some may occur during load testing. One typical method of determining battery health employs a load test. During this load test, the battery is disconnected from the power supply system and discharged across a load such as a resistor bank. The rate at which the cell voltage then decays is indicative of the battery's health and ability to sustain the power supply should the a.c. supply be cut. Weak battery cells display earlier and more rapid signs of voltage decay. The voltage decay characteristic obtained during a load test correlates well with the expected performance, but the test is labour intensive and cannot easily be performed with the battery connected to the operating uninterruptable power supply. Furthermore, battery lifetime is reduced as a result of the required discharge.

To prolong battery lifetime, therefore, modes of

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testing that do not involve large discharges have been developed. For example, reducing the depth of discharge during battery testing greatly improves battery lifetime. An alternative to load testing is to use impedance measurements to determine battery condition.

Any device through which an electrical current will flow exhibits an impedance to that flow. In a lead acid battery the impedance comprises pure resistance components such as the battery terminals, plates, and the resistance of the electrochemical path, and capacitative components, in particular of the parallel plates. The impedance of the battery will therefore depend on the frequency at which it is measured. Detailed analysis of battery impedance measurements is difficult, requiring complex calculations. No universal equivalent circuit is available to describe the response of even a single electrode. The situation is yet more complicated when considering complete cells or batteries, with the influence on impedance of all the individual components being difficult or impossible to separate. For this reason, battery impedance measurements in practice are usually limited to one or a few impedance measurements at fixed frequencies. Deviations of a single cell from a norm may then indicate that this cell is faulty.

Although the battery resistance can be measured using a d.c discharge across two or more different loads, battery lifetime may be affected by the significant discharge required to obtain repeatable readings, and a long measurement cycle is needed to ensure that battery recovers before taking measurements from the next cell. These problems do not occur during an a.c. impedance measurement. A variety of frequencies have been suggested or used for such measurements, ranging

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from 10Hz to 1mHz. A signal generator is used to apply an a.c. signal of the required frequency to individual cells or to the whole battery. Current and voltage readings are then made to determine the impedance of individual cells.

By use of an on-line monitor it is possible to look for changing cell float voltages and cell impedance values that signal that the characteristics of the cell are changing. In such an application it does not matter that a physically correct value of impedance is not returned by the monitor. Rather, the monitor needs to determine whether a measure of the impedance of a given cell or group of cells has changed significantly over time, perhaps with respect to some baseline or norm, or whether the measure of impedance of one cell or group of cells is significantly different from the battery average. Long term stability is an important indicator of cell performance and health. The skilled and experienced person is able to make a decision to make further checks on a cell or group of cells, perform repairs or install a replacement, based on the measurements of impedance. Automatic monitoring equipment, perhaps embodied in a computer connected to a telecommunications link, may be used to assist in this process.

Impedance monitors of the prior art have measured cell impedance by injecting an a.c. signal of a given frequency into the battery and by filtering measurements of voltage and current at the same frequency. Because of the large capacity of the batteries used in uninterruptable power supplies the signal generator may need to be of a considerable size.

It is an object of the present invention to provide an

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improved method for determining the condition of cells within the batteries of uninterruptable power supplies.

5 According to the present invention, there is provided a method of measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the method comprising: measuring at  
10 the battery cell or cells and an a.c. component of a voltage across the said battery cell or cells, the a.c. component arising from a ripple current in the said battery cell or cells in use; and determining the electrical efficacy of the cell or cells on the basis  
15 of the or at least one of the measured a.c. current and voltage components.

The ripple current in the battery results from the normal operation of the uninterruptable power supply.  
20 In particular, it may result from the operation of those components converting between direct and alternating current. Electrical signals related to the ripple current include the ripple current itself and ripple voltages driving or driven by the ripple  
25 current.

Preferably, the step of determining the electrical efficacy includes obtaining a numerical value from the, or at least one of the, measured a.c. current and  
30 voltage components.

In that case, the electrical efficacy of the or each battery cell may be determined by comparison of the said numerical value with a corresponding further  
35 numerical value obtained by measurement of a.c. current and/or voltage components from one or more different cells. The electrical efficacy may in a

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particularly preferred embodiment be determined by comparison of the said numerical value with the average of a plurality of further numerical values obtained by measurement of a.c. current and/or voltage components from a corresponding plurality of separate arrays of single or multiple cells respectively.

Alternatively, the electrical efficacy of the battery cell or cells may be determined by comparison of the said numerical value with a corresponding predetermined numerical value.

The method may further comprise the steps of measuring both the a.c. component of current through the battery cell or cells and the a.c. component of the voltage across the battery cell or cells; and obtaining a value for the internal impedance of the battery cell or cells via a combination of the said current component and the said voltage component.

Although the impedance of the cell or cells is measured in preference, other parameters may be conveniently assessed, as will be apparent to the person skilled in the art. For example the resistive, capacitative or inductive components of the battery impedance, or the power dissipated in the cell or group of cells within a given frequency band may be determined. These and other parameters may be of use in assessing the condition of the cell or group of cells.

Preferably, the step of measuring at least one of the a.c. components of a current and a voltage includes the steps of: measuring electrical signals representative of at least one of the voltage level across the cell or cells and the current level through the cell or cells; and frequency filtering the or each



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measured electrical signal to extract the said a.c. component arising from the ripple current. In that case, the step of filtering includes isolating a band of frequencies from the or each said electrical signals.

The band of frequencies may include at least one harmonic frequency of the a.c. mains frequency, such as harmonics of 50 Hz or 60 Hz. Most preferably, components at 900 Hz and 1080 Hz are chosen.

The invention also extends to an apparatus for measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the apparatus comprising an ammeter arranged to measure an a.c. component of a current through the battery cell or cells, the a.c. current component arising from a ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of the measured a.c. current component.

In yet a further aspect, the invention resides in an apparatus for measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the apparatus comprising a voltmeter arranged to measure an a.c. component of a voltage across the battery cell or cells, the a.c. voltage component arising from a ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of the measured a.c. voltage component.

In that case, the apparatus may further comprise an ammeter arranged to measure an a.c. component of a current flowing through the battery cell or cells, the a.c. current component also arising from the said

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ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of both the measured a.c. voltage component and the a.c. current component.

5

A filter such as a fifth order band pass filter may also be provided to isolate harmonic frequencies of mains frequencies, for example.

10

Advantageously, apparatus according to the present invention may be characterised in that it does not comprise a signal generator for injecting a current into the battery.

15

Embodiments of the present invention will now be described by way of example only and with reference to the drawings, of which:

Figure 1 shows a typical arrangement of an uninterruptable power supply;

20

Figure 2 is a schematic diagram showing apparatus for measuring the impedance of cells or groups of cells in a battery for an uninterruptable power supply; and

25

Figure 3 is a schematic diagram showing apparatus embodying the present invention, for measuring the voltage across cells or groups of cells of a battery of an uninterruptable power supply.

30

Alternating current methods of measuring impedance in battery cells have hitherto required the injection of an alternating current into the battery string. The method of the present invention utilises electrical signals related to the inherent ripple current present in almost all uninterruptable power supply batteries.

35

Ripple current is caused by the power supply utilising the power storage capacity of the battery. The battery

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is used to provide current for the inverter to produce an a.c. current from the d.c. bus voltage. This ripple current typically has a waveform that repeats at least at the frequency of the alternating current supplied by the inverter, but also contains many higher order harmonics and noise. The peak to peak magnitude of the ripple current is typically 20% to 100% of the actual load current supplied by the inverter. The ripple current is associated with related electrical signals, in particular, ripple voltages across various battery components.

One embodiment of the invention will now be described with reference to Figure 2 which shows, schematically, an apparatus for measuring the impedance of cells or groups of cells in a battery for an uninterruptable power supply.

As seen in Figure 2, a number of cells 11 are together constituting a battery 30 connected in series across a d.c. bus 10, 12 of an uninterruptable power supply. The cells 11 make up the battery used to maintain the voltage of the d.c. bus during a period when the a.c. supply 1 (Figure 1) is cut. The cells are typically supplied grouped into units which are then installed in the uninterruptable power supply. A whole unit may then be replaced if found to be faulty.

An ammeter 13 is connected in series with the cells 11 and measures the instantaneous current flowing through the battery at a selected frequency.

A voltmeter 14 is likewise connected in parallel with the cells 11 and measures the instantaneous voltages across each of the cells 11, again at the selected frequency. The apparatus may conveniently be protected by individual current limiting protection resistors

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and the voltages measured using a number of divider resistor networks, yielding voltage signals from the junction between each cell. These features will be described in more detail with reference to Figure 3 below.

At any one time, the current measurement or the voltage measurement of a particular cell is selected by a multiplexer array 15, under the control of a central processing unit (CPU) 20. Typically the multiplexer array 15 may select the voltage measurement signals from both sides of a cell. As will be described in connection with Figure 3, these signals may then be buffered before a differentiator circuit removes the d.c. components and a subtractor circuit converts the differential of the two signals to a single bipolar signal.

The current or voltage signal selected by the multiplexer array is filtered using a high order band pass filter 16 arranged to pass a narrow band of frequencies around a selected frequency. The resulting filtered signal is converted to a d.c. voltage using a root-mean-square a.c. to d.c. converter 17 and is sampled using an analogue to digital converter 18. The resulting digital data is read by the CPU 20, which is linked to each of the multiplexer array 15, band pass filter 16, a.c. to d.c. converter 17 and analogue-to-digital converter 18 by a control line 19.

The high order band pass filter may be centred on a frequency that is selected to best indicate battery condition. A frequency of 900Hz may be chosen in the United Kingdom and Europe where the frequency of the external a.c. supply is 50Hz. Similarly, in the United States of America a central filter frequency of 1080Hz may be chosen for use with 60 Hz mains a.c.

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Measurements of battery impedance at various other frequencies, however, have been found to yield good indications of battery condition, and any suitable frequency may be used. A clock sweepable 5th order band pass filter under the control of a programmable clock filter has been found to provide good results in the operation of the present apparatus, and allows the central frequency of the filter to be varied conveniently if required. Other filter arrangements may be equally suitable.

The CPU 20 calculates the ratios of the digitised voltage and current data to yield measurements of the impedance of the battery cells. By means of the multiplexer, the CPU 20 is able to sequentially select the voltage signal of each cell 11. The CPU may record the measurements of impedance, preferably in a non-volatile memory and/or on a mass storage device such as a magnetic device (not shown).

It is not necessary for calibrated measurements of impedance to be obtained, since the conditions of the cells of the battery can be assessed by monitoring changes in impedance over time, or by comparing the simultaneous impedances of a cell to other cells or the battery average.

By means of a telecommunications link 21, the CPU 20 may be remotely interrogated to obtain the impedance measurements. An assessment of the conditions in the battery may then be made. The CPU 20 may conveniently be programmed to monitor the impedance measurements to raise an alarm via the telecommunications link 21 if any significant changes in impedance occur, such as changes of the impedance of a single cell that exceed a preset threshold, or the impedance of a single cell

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differing from the battery average by more than a preset threshold.

5 The apparatus shown may be used to measure the impedance of cells of the battery. By monitoring how the measurement of impedance of individual cells or groups of cells changes over time, the skilled person is able to obtain an indication of the conditions of individual cells, for example on observing an increase  
10 in the impedance of a single cell that is characteristic of a fault in or problem with that cell.

15 Similar apparatus may be used to monitor other parameters of individual cells or groups of cells. The power dissipated by a cell within a given frequency band, or the resistive, capacitative or inductive components of the impedance may, for example, be useful for obtaining an indication of the conditions  
20 of individual cells, and may be monitored using variations to the described apparatus that will be familiar to the person skilled in the art.

Figure 3 shows, schematically an apparatus for  
25 measuring the voltage across cells or groups of cells within the battery of an uninterruptable power supply. The diagram illustrates a particular configuration of apparatus that may be used to implement the voltage measurement function of the apparatus shown in Figure  
30 2. Accordingly, features common to Figures 2 and 3 are labelled with like reference numerals.

The battery 30 comprises a number of cells or groups of cells 11. Electrical connections from the junctions  
35 between each cell or group of cells 11 to a voltage measuring apparatus are made through current limiting protection resistors 31 and through pickup wires 32.

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The current limiting protection resistors 31 protect the voltage measuring apparatus from current surges and electrical damage.

5     The pickup wires 32 connect the current limiting protection resistors 31 to an array of divider resistor networks 33 configured to scale the voltages being measured to a level appropriate for the electronic circuits that follow.

10     A multiplexer array 15 samples each pair of adjacent voltage measurements in turn. The pair of voltage outputs from the multiplexer array 15 passes through buffers 35 and to a differentiator 36 which removes  
15     the d.c. component of the signal. The resultant pair of voltage outputs is then passed to a subtractor 37 which converts the differential voltage input signal to a single bipolar output signal. The single voltage output from the subtractor 37 is then filtered by a  
20     clock sweepable fifth order band pass filter 16. The central frequency of the band pass filter is controlled by a programmable clock 39. A central frequency for the filter may be chosen to best indicate battery condition as described above.

25     The filtered signal is passed through a root-mean-square (r.m.s.) to d.c converter 17 to convert the filtered alternating signal to a d.c. voltage which is sampled by an analogue to digital converter 18. A  
30     digital output 42 from the analogue-to-digital converter may be passed to a central processing unit as described in connection with Figure 2.

35     An equivalent apparatus may be provided for measuring the current passing through the battery, employing a similar filter, root mean square to d.c. converter and analogue to digital converter. Alternatively, an

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ammeter or other circuitry may be provided between the battery 30 and the multiplexer array 15 to enable the apparatus to sample the ripple current as well. In either case, the digital output that represents the measured current is passed to the central processing unit for the purposes of calculating the impedance of each cell or group of cells.

Typically, batteries for uninterruptable power supplies comprise multiple cells grouped into units. It will be understood that the apparatus described herein is equally suitable for measuring individual cells, groups of cells or indeed the whole battery, as desirable. It will also be appreciated that the specific implementation of the various features shown in Figure 3 is a matter of design choice. For example, discrete analogue or digital components might be used, or integrated circuits as appropriate. Alternatively, software filtering and software calculation of the root-mean-square to d.c. function could be employed. Likewise, common components may be used to process both the voltage and current components, or separate circuits could be used.

If only a very small amount of ripple current flows through the battery of an uninterruptable power supply system, and this current is insufficient for the effective operation of the impedance measurement equipment, then a signal generator may be provided to inject current into the system during times of impedance measurement.



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CLAIMS

1. A method of measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the method comprising:  
5       measuring at least one of an a.c. component of a current through the battery cell or cells and an a.c. component of a voltage across the said battery cell or cells, the a.c. component arising from a ripple  
10       current in the said battery cell or cells in use; and  
          determining the electrical efficacy of the cell or cells on the basis of the or at least one of the measured a.c. current and voltage components.
- 15       2. The method of claim 1, in which the step of determining the electrical efficacy includes obtaining a numerical value from the, or at least one of the, measured a.c. current and voltage components.
- 20       3. The method of claim 2, in which the electrical efficacy of the or each battery cell is determined by comparison of the said numerical value with a corresponding further numerical value obtained by measurement of a.c. current and/or voltage  
25       components from one or more different cells.
- 30       4. The method of claim 3, in which the electrical efficacy is determined by comparison of the said numerical value with the average of a plurality of further numerical values obtained by measurement of a.c. current and/or voltage components from a corresponding plurality of separate arrays of single or multiple cells respectively.
- 35       5. The method of claim 2, in which the electrical efficacy of the battery cell or cells is determined by comparison of the said numerical value

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with a corresponding predetermined numerical value.

6. The method of any one of the preceding claims, further comprising the steps of measuring both  
5 the a.c. component of current through the battery cell or cells and the a.c. component of the voltage across the battery cell or cells; and obtaining a value for the internal impedance of the battery cell or cells via a combination of the said current component and  
10 the said voltage component.

7. The method of any one of the preceding claims, in which the step of measuring at least one of the a.c. components of a current and a voltage  
15 includes the steps of:

measuring electrical signals representative of at least one of the voltage level across the cell or cells and the current level through the cell or cells; and  
20 frequency filtering the or each measured electrical signal to extract the said a.c. component arising from the ripple current.

8. The method of claim 7, in which the steps of  
25 filtering includes isolating a band of frequencies from the or each said electrical signals.

9. The method of claim 7, in which the step of filtering includes isolating a band of frequencies  
30 including those frequencies which include at least one harmonic frequency of the a.c. mains frequency.

10. The method of claim 9, including isolating a band of frequencies around 900 Hz.  
35

11. The method of claim 9, including isolating a band of frequencies around 1080 Hz.

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12. An apparatus for measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the apparatus comprising an ammeter arranged to measure an a.c. component of a current through the battery cell or cells, the a.c. current component arising from a ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of the measured a.c. current component.

13. An apparatus for measuring the electrical efficacy of one or more battery cells for use in an uninterruptable power supply, the apparatus comprising a voltmeter arranged to measure an a.c. component of a voltage across the battery cell or cells, the a.c. voltage component arising from a ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of the measured a.c. voltage component.

14. An apparatus as claimed in claim 13, further comprising an ammeter arranged to measure an a.c. component of a current flowing through the battery cell or cells, the a.c. current component also arising from the said ripple current in the said battery cell or cells in use, the electrical efficacy of the cell or cells being determined on the basis of both the measured a.c. voltage component and the a.c. current component.

15. An apparatus as claimed in claim 14, in which the electrical efficacy is determined on the basis of an impedance calculated from the ratio of the said measured a.c. voltage component to the said measured a.c. current component.

16. An apparatus as claimed in any one of claims

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12 to 15, further comprising a frequency filter arranged to pass a band of frequencies including the frequency of the a.c. component arising from the ripple current.

5

17. An apparatus as claimed in claim 16 in which the filter is a fifth order band pass filter.

10 18. An apparatus as claimed in claim 16 or claim 17, in which the filter is arranged to pass a band of frequencies including at least one harmonic frequency of an a.c. mains frequency.

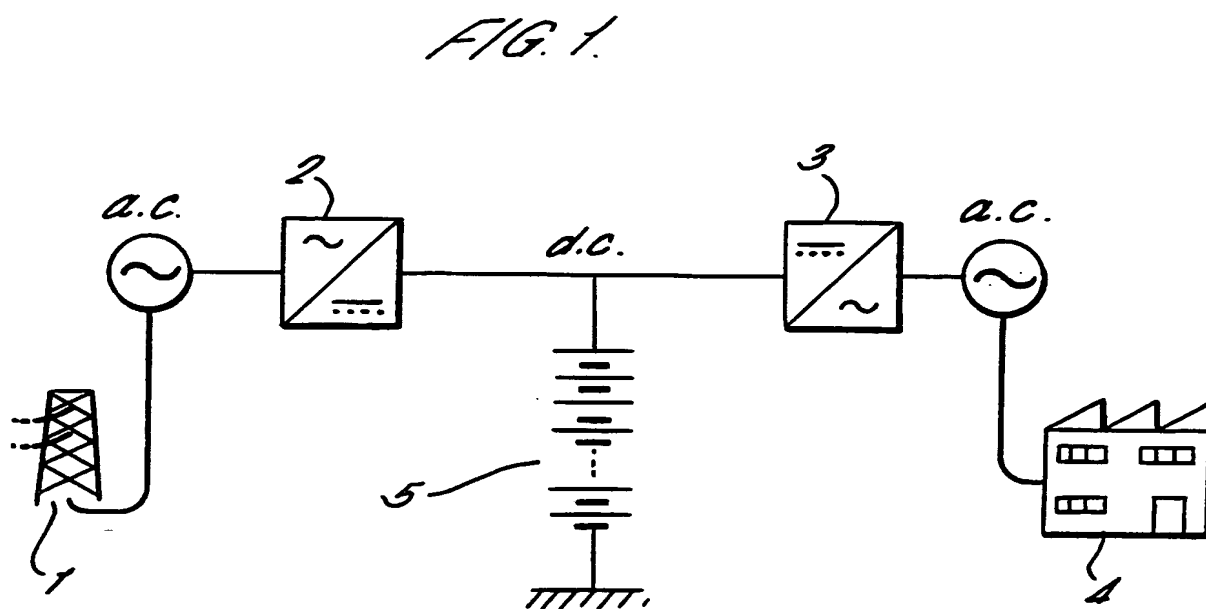
15 19. An apparatus as claimed in claim 18, in which the filter is arranged to pass a band of frequencies including 900 Hz.

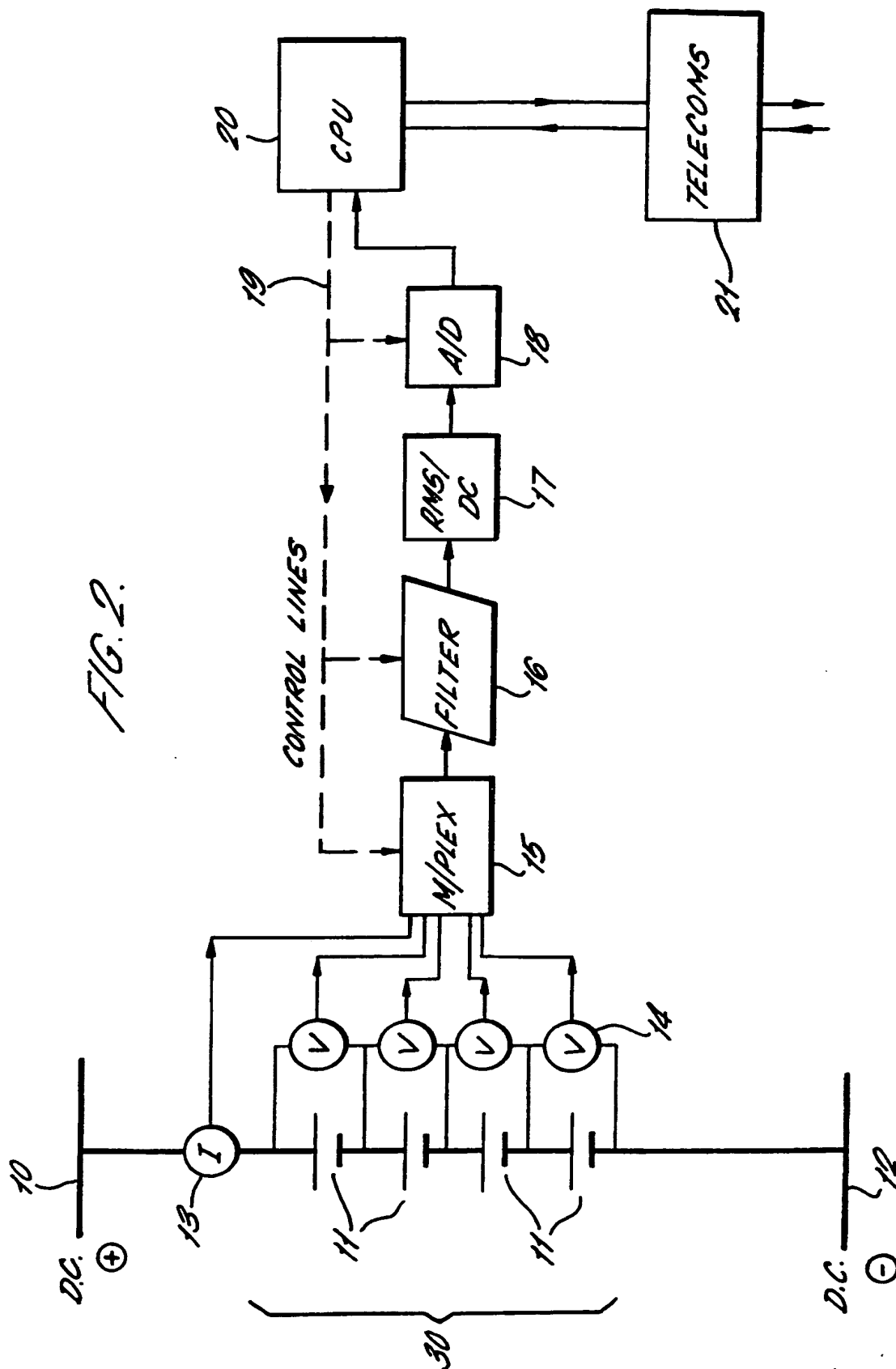
20 20. An apparatus as claimed in claim 18, in which the filter is arranged to pass a band of frequencies including 1080 Hz.

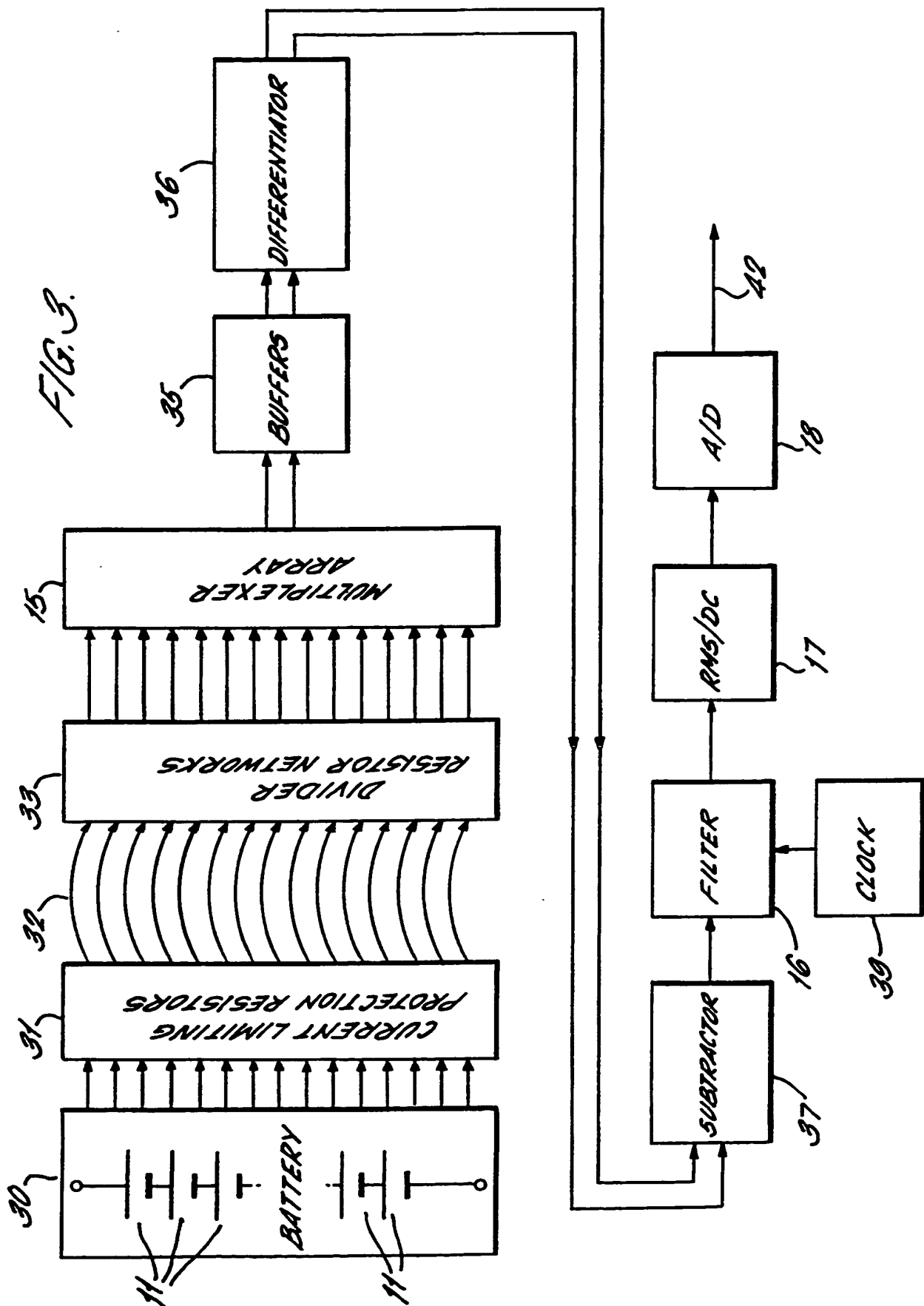
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# INTERNATIONAL SEARCH REPORT

Intern. Application No

PCT/GB 00/02992

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 G01R31/36

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 06, 30 April 1998 (1998-04-30) & JP 10 056744 A (SHIN KOBE ELECTRIC MACH CO LTD), 24 February 1998 (1998-02-24) abstract	1,2,6,7, 12,13
X	US 5 457 377 A (JONSSON LENNART ET AL) 10 October 1995 (1995-10-10) column 3, line 3 - line 17; claim 1	1,12,13
A	US 4 697 134 A (GABRIEL CHARLES M ET AL) 29 September 1987 (1987-09-29) claim 16; figure 3	1,8
A	WO 98 53335 A (JOKINEN USKO) 26 November 1998 (1998-11-26) claims 1,4	1,8

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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\*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*G\* document member of the same patent family

Date of the actual completion of the international search

22 December 2000

Date of mailing of the international search report

02/01/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Six, G



# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/02992

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 10056744 A	24-02-1998	NONE	
US 5457377 A	10-10-1995	FI 924425 A DE 4333520 A GB 2271229 A, B	02-04-1994 07-04-1994 06-04-1994
US 4697134 A	29-09-1987	AT 68268 T AU 8033587 A DE 3773645 A DE 3773645 D EP 0276305 A HK 135794 A SG 136094 G WO 8801055 A	15-10-1991 24-02-1988 14-11-1991 14-11-1991 03-08-1988 09-12-1994 13-01-1995 11-02-1988
WO 9853335 A	26-11-1998	FI 972135 A AU 7531198 A EP 0986762 A	02-12-1998 11-12-1998 22-03-2000

## PATENT COOPERATION TREATY

## PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference <b>NAM52052/001</b>	<b>FOR FURTHER ACTION</b> see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. <b>PCT/GB 00/ 02992</b>	International filing date (day/month/year) <b>03/08/2000</b>	(Earliest) Priority Date (day/month/year) <b>03/08/1999</b>
Applicant <b>ELLIOTT INDUSTRIES LIMITED et al.</b>		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

## 1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

2

☐ None of the figures.

## INTERNATIONAL SEARCH REPORT

International Application No

P B 00/02992

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 G01R31/36

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 1998, no. 06, 30 April 1998 (1998-04-30) & JP 10 056744 A (SHIN KOBE ELECTRIC MACH CO LTD), 24 February 1998 (1998-02-24) abstract	1,2,6,7, 12,13
X	US 5 457 377 A (JONSSON LENNART ET AL) 10 October 1995 (1995-10-10) column 3, line 3 - line 17; claim 1	1,12,13
A	US 4 697 134 A (GABRIEL CHARLES M ET AL) 29 September 1987 (1987-09-29) claim 16; figure 3	1,8
A	WO 98 53335 A (JOKINEN USKO) 26 November 1998 (1998-11-26) claims 1,4	1,8



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*G\* document member of the same patent family

Date of the actual completion of the international search

22 December 2000

Date of mailing of the international search report

02/01/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Six, G

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

P 00/02992

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 10056744 A	24-02-1998	NONE	
US 5457377 A	10-10-1995	FI 924425 A DE 4333520 A GB 2271229 A, B	02-04-1994 07-04-1994 06-04-1994
US 4697134 A	29-09-1987	AT 68268 T AU 8033587 A DE 3773645 A DE 3773645 D EP 0276305 A HK 135794 A SG 136094 G WO 8801055 A	15-10-1991 24-02-1988 14-11-1991 14-11-1991 03-08-1988 09-12-1994 13-01-1995 11-02-1988
WO 9853335 A	26-11-1998	FI 972135 A AU 7531198 A EP 0986762 A	02-12-1998 11-12-1998 22-03-2000

# PATENT COOPERATION TREATY

Mr. Mcleish (JRP)  
 ucr- 218/01  
 OL - 30/9/01

From the:  
 INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

BOULT WADE TENNANT  
 Verulam Gardens  
 70 Gray's Inn Road  
 London WC1X 8BT  
 GRANDE BRETAGNE

RECEIVED

02 AUG 2001

BOULT WADE TENNANT

PCT

WRITTEN OPINION

(PCT Rule 66)

Date of mailing  
 (day/month/year)

31.07.2001

Applicant's or agent's file reference

NAM/JRP/P52052/001

REPLY DUE

within 2 month(s)  
 from the above date of mailing

International application No.

PCT/GB00/02992

International filing date (day/month/year)

03/08/2000

Priority date (day/month/year)

03/08/1999

International Patent Classification (IPC) or both national classification and IPC

G01R31/36

Applicant

ELLIOTT INDUSTRIES LIMITED et al.

1. This written opinion is the first drawn up by this International Preliminary Examining Authority.

2. This opinion contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain document cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

3. The applicant is hereby invited to reply to this opinion.

**When?** See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).


**How?** By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

**Also:** For an additional opportunity to submit amendments, see Rule 66.4.  
 For the examiner's obligation to consider amendments and/or arguments, see Rule 66.4 bis.  
 For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: 03/12/2001.

Name and mailing address of the international preliminary examining authority:

 European Patent Office  
 D-80298 Munich  
 Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
 Fax: +49 89 2399 - 4465

Authorized officer / Examiner

Jakob, C

Formalities officer (incl. extension of time limits)

ANDREATTA, R

Telephone No. +49 89 2399 7581



**I. Basis of the opinion**

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed"*):

**Description, pages:**

1-14 as originally filed

**Claims, No.:**

1-20 as originally filed

**Drawings, sheets:**

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

## WRITTEN OPINION

International application No. PCT/GB00/02992

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

### V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement
- |                               |        |                  |
|-------------------------------|--------|------------------|
| Novelty (N)                   | Claims | 1-3, 5, 6, 12-15 |
| Inventive step (IS)           | Claims | 4, 7-11, 16-20   |
| Industrial applicability (IA) | Claims |                  |

2. Citations and explanations  
**see separate sheet**

### VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

## Section V.2

1. Reference is made to the following documents:

D1: US-A-5 457 377;  
D2: WO-A-93 25917;  
D3: PATENT ABSTRACTS OF JAPAN vol. 1998, no. 06, 30 April 1998 &  
JP 10 056744 A;  
D4: US-A-5 744 932.

The documents D2 and D4 were not cited in the International Search Report.  
Copies of these documents are appended hereto (see also Article 33(6) PCT).

2. The subject-matter of claims 1 to 3, 5, 6 and 12 to 15 is not considered as being new in the sense of article 33(2) PCT for the following reasons:
- 2.1. Claims 1, 12 and 13 and 14: Document D1 discloses determining the electrical efficacy of battery cells (1) suitable for use in an uninterruptable power supply (cf. D1, claims 1 and 8) by
- measuring respective AC components of the battery current as well as of the battery voltage (cf. D1, column 2, lines 8 to 12) by means of current and voltage measuring devices (see e.g. D1, figure 2, reference signs 9a and c; see also column 3, lines 23 to 25), the AC components arising from a ripple current in said battery in use (cf. D1, column 3, lines 3 to 7); and
  - determining said electrical efficacy based on these AC components (cf. D1, column 3, lines 9 to 12 and 18 to 22; see also column 1, lines 58 to 61).
- Documents D2 to D4 disclose similar methods and apparatuses.
- 2.2. Claims 2, 5, 6 and 15: In addition to measuring AC components of the battery current and voltage, document D1 discloses deriving a numerical value ( $Z_B$ , see D1, column 3, lines 9 to 12) representing the internal impedance of the battery from both of these measured AC components, as well as determining the electrical efficacy of the battery by comparing this impedance value with a predetermined numerical impedance value ( $Z_{max}$ , see e.g. D1, claims 1 and 8).



- 2.3. Claim 3: Document D2 discloses determining the state of different cells of a battery by comparing digital values obtained by measuring AC currents and voltages corresponding to these cells (see e.g. D2, page 3, lines 16 to 18 and the embodiment associated with figure 3).
3. The subject-matter of dependent claims 4, 7 to 11 and 16 to 20 is not considered as involving an inventive step as required by Article 33(3) PCT for the following reasons:
- 3.1. Claim 4: Document D1, which is considered to represent the most relevant state of the art, discloses determining the electrical efficacy of the battery by comparing the measured impedance value  $Z_B$  to a predetermined reference value  $Z_{max}$  (see sections V.2 2.1 and 2.2 above). Although not explicitly mentioned in the documents cited above, selecting this reference value based on an average of measured values obtained from different batteries or cells, e.g. "known good" samples, appears to be one of several straightforward design options from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill.
- 3.2. Claims 7, 8 and 16: It is generally known in the art that in order to extract an AC component from a signal with a superimposed DC component (as e.g. ripple-contaminated battery currents or voltages), frequency filtering might be useful. In these circumstances, the skilled person would therefore consider applying e.g. a high pass filtering or a band pass filtering of the voltage or the current signals to the method described in document D1.
- 3.3. Claims 9 and 18: If the AC component to extract has a constant frequency, it is further obvious to employ band pass filtering such that the frequencies passing the filter include at least one harmonic frequency contained in said AC component.
- 3.4. Claims 10, 11, 17, 19 and 20: The features of these claims merely concern the selection of a value of a filter parameter. The skilled person would carry out such a selection, in case of need, without the exercise of inventive skill in order to

achieve the desired filter characteristic (cf. the PCT Guidelines, PCT/GL/3 IV, 8.8(C1)(ii)). Additionally, no particular technical effects corresponding to the claimed values are disclosed in the present application.

## **Section VII**

- 1.1. The independent claims 1, 12 and 13 include features disclosed in document D1 (see section V.2. 2.1 above). These claims should therefore be cast in the two-part form, as required by Rule 6.3(b) PCT, with all the features known from D1 placed in the preamble (see also the PCT Guidelines PCT/GL/3 III, 2.3a).
  - 1.2. To meet the requirements of Rule 5.1(a)(ii) PCT, the documents D1 and D2 should be identified in the description and the relevant background art disclosed therein should be discussed (see also the PCT Guidelines PCT/GL/3 II, 4.4).
  - 1.3. The features of the claims are not provided with reference signs placed in parentheses as required by Rule 6.2(b) PCT (see also the PCT Guidelines PCT/GL/3 III, 4.11).
- 
- 2.1. The applicant is requested to file amended claims taking account of the above comments by way of replacement pages in the manner stipulated by Rule 66.8(a) PCT. To provide full support to the amended claims as required by Article 6 PCT, adapting the description may be necessary (see also Rule 5.1(a)(iii) PCT).

As to the submission of amended claims, the attention of the applicant is further drawn to the fact that amended claims may neither contain

- subject-matter which extends beyond the content of the application as filed (Article 34(2) b) PCT; see also the PCT Guidelines, PCT/GL/3 PG-VI, 7.9), nor
- subject-matter in respect of which no International Search Report has been established (Rule 66.1 (e) PCT; see also the PCT Guidelines, PCT/GL/3 PG-VI, 5.4)).

**WRITTEN OPINION  
SEPARATE SHEET**

---

International application No. PCT/GB00/02992

2.2. To facilitate the examination of the amended application with regard to the requirements of Article 34(2)b) PCT, the applicant is invited

- to identify clearly the amendments carried out, and
- to indicate the passages of the application as filed on which these amendments are based

(see Rule 66.8 PCT and the PCT Guidelines PCT/GL/3 VI, 7.2).

# PATENT COOPERATION TREATY

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

BOULT WADE TENNANT  
Verulam Gardens  
70 Gray's Inn Road  
London WC1X 8BT  
GRANDE BRETAGNE

RECEIVED

24 OCT 2001

BOULT WADE TENNANT

NOTIFICATION OF TRANSMITTAL OF  
THE INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT  
(PCT Rule 71.1)

Date of mailing  
(day/month/year) 22.10.2001

Applicant's or agent's file reference  
NAM/JRP/P52052/001

## IMPORTANT NOTIFICATION

International application No.  
PCT/GB00/02992

International filing date (day/month/year)  
03/08/2000

Priority date (day/month/year)  
03/08/1999

Applicant

ELLIOTT INDUSTRIES LIMITED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

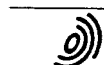
#### 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office  
D-80298 Munich  
Tel. +49 89 2399 - 0 Tx: 523656 epmu d  
Fax: +49 89 2399 - 4465

Authorized officer

Baumann, H

Tel. +49 89 2399-2131



# ATENT COOPERATION TREATY

## PCT

### INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>NAM/JRP/P52052/001</b>	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. <b>PCT/GB00/02992</b>	International filing date (day/month/year) <b>03/08/2000</b>	Priority date (day/month/year) <b>03/08/1999</b>
International Patent Classification (IPC) or national classification and IPC <b>G01R31/36</b>		
Applicant <b>ELLIOTT INDUSTRIES LIMITED et al.</b>		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 6 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand  <b>01/03/2001</b>	Date of completion of this report  <b>22.10.2001</b>
Name and mailing address of the international preliminary examining authority:   <b>European Patent Office</b> <b>D-80298 Munich</b> <b>Tel. +49 89 2399 - 0 Tx: 523656 epmu d</b> <b>Fax: +49 89 2399 - 4465</b>	Authorized officer  <b>Jakob, C</b>  Telephone No. +49 89 2399 8948  

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02992

**I. Basis of the report**

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

**Description, pages:**

1-14 as originally filed

**Claims, No.:**

1-20 as originally filed

**Drawings, sheets:**

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/GB00/02992

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)	Yes:	Claims	4,7-11,16-20
	No:	Claims	1-3, 5, 6, 12-15
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-20
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

---

International application No. PCT/GB00/02992

**Section V.2**

1. Reference is made to the following documents:

D1: US-A-5 457 377;  
D2: WO-A-93 25917;  
D3: PATENT ABSTRACTS OF JAPAN vol. 1998, no. 06, 30 April 1998 &  
JP 10 056744 A;  
D4: US-A-5 744 932.

The documents D2 and D4 were not cited in the International Search Report (see also Article 33(6) PCT).

2. The subject-matter of claims 1 to 3, 5, 6 and 12 to 15 is not considered as being new in the sense of article 33(2) PCT for the following reasons:

- 2.1. Claims 1, 12 and 13 and 14: Document D1 discloses determining the electrical efficacy of battery cells (1) suitable for use in an uninterruptable power supply (cf. D1, claims 1 and 8) by
- measuring respective AC components of the battery current as well as of the battery voltage (cf. D1, column 2, lines 8 to 12) by means of current and voltage measuring devices (see e.g. D1, figure 2, reference signs 9a and c; see also column 3, lines 23 to 25), the AC components arising from a ripple current in said battery in use (cf. D1, column 3, lines 3 to 7); and
  - determining said electrical efficacy based on these AC components (cf. D1, column 3, lines 9 to 12 and 18 to 22; see also column 1, lines 58 to 61).

Documents D2 to D4 disclose similar methods and apparatuses.

- 2.2. Claims 2, 5, 6 and 15: In addition to measuring AC components of the battery current and voltage, document D1 discloses deriving a numerical value (ZB, see D1, column 3, lines 9 to 12) representing the internal impedance of the battery from both of these measured AC components, as well as determining the electrical efficacy of the battery by comparing this impedance value with a predetermined numerical impedance value ( $Z_{max}$ , see e.g. D1, claims 1 and 8).



- 2.3. Claim 3: Document D2 discloses determining the state of different cells of a battery by comparing digital values obtained by measuring AC currents and voltages corresponding to these cells (see e.g. D2, page 3, lines 16 to 18 and the embodiment associated with figure 3).
3. The subject-matter of dependent claims 4, 7 to 11 and 16 to 20 is not considered as involving an inventive step as required by Article 33(3) PCT for the following reasons:
- 3.1. Claim 4: Document D1, which is considered to represent the most relevant state of the art, discloses determining the electrical efficacy of the battery by comparing the measured impedance value  $Z_B$  to a predetermined reference value  $Z_{max}$  (see sections V.2 2.1 and 2.2 above). Although not explicitly mentioned in the documents cited above, selecting this reference value based on an average of measured values obtained from different batteries or cells, e.g. "known good" samples, appears to be one of several straightforward design options from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill.
- 3.2. Claims 7, 8 and 16: It is generally known in the art that in order to extract an AC component from a signal with a superimposed DC component (as e.g. ripple-contaminated battery currents or voltages), frequency filtering might be useful. In these circumstances, the skilled person would therefore consider applying e.g. a high pass filtering or a band pass filtering of the voltage or the current signals to the method described in document D1.
- 3.3. Claims 9 and 18: If the AC component to extract has a constant frequency, it is further obvious to employ band pass filtering with a bandwidth such that the frequencies passing the filter include at least one harmonic frequency contained in said AC component.
- 3.4. Claims 10, 11, 17, 19 and 20: The features of these claims merely concern the selection of a value of a filter parameter. The skilled person would carry out such a selection, in case of need, without the exercise of inventive skill in order to

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achieve the desired filter characteristic (cf. the PCT Guidelines, PCT/GL/3 IV, 8.8(C1)(ii)). Additionally, no particular technical effects corresponding to the claimed values are disclosed in the application.

4. The subject-matter of claims 1 to 20 meets the requirements of Article 33(4) PCT with respect to industrial applicability (see also the PCT Guidelines PCT/GL/3 IV, 4.1).

**Section VII**

1. The independent claims 1, 12 and 13 of the application are not in the two-part form in accordance with Rule 6.3(b) PCT, which in the present case would be appropriate, since the features mentioned in section V.2. 2.1 above are known in combination from the document D1 (see also the PCT Guidelines PCT/GL/3 III-2.3 and 2.3a).
2. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D2 is not discussed in the description, nor are these documents identified therein.
3. The features of the claims are not provided with reference signs placed in parentheses as required by Rule 6.2(b) PCT (see also the PCT Guidelines PCT/GL/3 III, 4.11).